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Variability studies in mulberry germplasm for leaf quality characters under Jammu region

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Abstract
The present investigation was carried out at Regional Sericultural Research Station, Central Silk Board, Miran Sahib, Jammu during Spring, 2019 to evaluate eighteen mulberry germplasm for leaf quality parameters. Analysis of variance for leaf quality characters showed highly significant differences among the genotypes. Leaf moisture content was significantly higher in S-1635 followed by V-1 and C-4. Leaf moisture loss after 3 hours, 6 hours and 12 hours was significantly lowest in S-1635 and V-1 whereas higher moisture loss was recorded in AR-12. Similarly, moisture retention capacity of leaf after 3 hours, 6 hours and 12 hours of harvest was significantly higher in S-1635 followed by V-1 whereas lowest moisture retention capacity of leaf was observed in AR-12. The genotypes exhibiting higher leaf moisture content, lower leaf moisture loss and higher moisture retention capacity can be used as parents in the future breeding programmes for improvement in leaf quality characters in mulberry. Further, the wide genetic variability existing among the genotypes can be utilized in mulberry breeding programme for improvement of leaf quality characters.

Keywords: germplasm, leaf quality, moisture content, mulberry, variability

Introduction
Mulberry (*Morus* spp.) is the only food crop of silkworm (*Bombyx mori* L.) which feeds on its leaves and produces silk. The plants are mainly grown for its foliage and breeding of mulberry are directed towards higher foliage production. Mulberry belongs to the genus *Morus* of family Moraceae. Owing to unisexual flowers and cross fertilization, wider range of variation exists in natural populations. The nutritional composition of mulberry leaves influences the larval growth and cocoon production. Leaf quality of mulberry leaves is one of the important characters based on which mulberry varieties are being evaluated (Bongale *et al*., 1997) [1]. Availability of good quality leaf has great impact on the sustainability and profitability of sericulture industry. Better the quality of mulberry leaves greater are the possibilities of obtaining good cocoon crops.

Mulberry leaves contain carbohydrates, proteins, vitamins, minerals and moisture. Water content in mulberry leaves is considered as one of the criteria in estimating the leaf quality. Higher moisture content of mulberry leaves is one of the important factors and has a direct effect on growth and development of silkworms. Moisture content in mulberry leaves improves their ingestion, digestion and also the conversion of nutrition in silkworm (Magadum *et al*., 2020) [2]. Due to change in the mulberry leaf quality parameters, there will be great impact on the rearing performance of silkworm and silk quality.

The present scenario of sericulture enterprise needs new varieties appropriate for different agro-climatic situations. Suitable parent material needs to be identified from large number of germplasm accessions for the purpose. The genetic improvement of mulberry depends on the availability of genetic variability in germplasm. Selection of suitable genotypes from genepool requires a thorough knowledge on foliage characters for utilizing them in hybridization programmes (Rahman *et al*., 2006) [3]. The extent of magnitude of genetic variability in the mulberry germplasm helps in the crop improvement through conventional breeding. The precise information on the nature and degree of genetic variability and diversity helps the plant breeder in choosing the diverse parents for purposeful hybridization. Prior knowledge of existence of variability for leaf quality characters is very essential to formulate a breeding strategy for improvement in leaf quality traits. Therefore, the present study was undertaken to know extent of variability present in the mulberry germplasm for different leaf quality characters under Jammu region.

Materials and Methods

Experimental site and material

The present study was conducted at Regional Sericultural Research Station (RSRS), Central Silk Board, CSB Complex, Miran Sahib, Jammu during Spring, 2019. The experimental material comprised of 18 mulberry genotypes *viz*., V-1, K-2, Sujanpur local, TR-10, Chak Majra, Chinese white, S-146, C-4, BR-2, AR-14, AR-12, AR-10, S-41, S-13, BC-259, S-1, MS-9404 and S-1635 maintained at a spacing of 90 cm x 90 cm as bush plantation at mulberry germplasm block of the station and managed by following the recommended agronomic package of practices.

Experimental data

The data on different leaf quality parameters like leaf moisture content (%), leaf moisture loss (%) after 3, 6 and 12 hours of harvest and moisture retention capacity of leaves (%) after 3, 6 and 12 hours after harvest were recorded from randomly sampled three replications. Middle leaves of the shoot at 45 days after pruning were collected for leaf quality analysis.

Statistical analysis and estimation of genetic parameters

The mean data of the above mentioned traits were statistically analyzed, using the standard method suggested by Clewer and Scarisbrick (2001) [4], using TNAUSTAT statistical package. Analysis of variance (ANOVA) was done by the method suggested by Panse and Sukhatme (1985) [5].

Results and Discussion

Genetic variability in any crop is a pre-requisite to initiate the breeding programme for the selection of superior entries over the existing cultivars. In addition to maintaining the pure stocks of the entries, it is also essential to make a systematic assessment of the extent of variability present for various yield components for effective selection of genotypes to bring about improvement in the desired direction (Saini *et al*., 2018) [6].

High leaf moisture content and moisture retention capacity of the mulberry genotypes has a positive influence on the growth and development of silkworm. For successful rearing the maintenance/retention of sufficient moisture content in the leaves for prolonged periods is of immense important. Different genotypes are said to influence the leaf moisture content and its retention in harvested leaf. Besides, environmental factors, leaf anatomical parameters like stomatal size, stomatal frequency, mesophyll tissue, cuticle thickness and leaf thickness also influence the moisture content of the leaf and its retention capacity. The nutritional qualities of leaves play an important role in silkworm rearing, higher moisture content is known to increase the amount of ingestion and digestibility of silkworm because moisture act as an olfactory and gustatory stimulant.

The analysis of variance among 18 mulberry genotypes indicated highly significant differences among them for all the leaf quality characters indicating presence of sufficient amount of variability in respect of all the traits studied (Table 1). The genotypic differences were significant at P=0.01. Similar results are reported by Sujathamma and Dandin (2000) [7], Tikader and Roy (2003) [8], Khan *et al*. (2007) [9], Jalaja Kumar and Rama Rao (2008) [10], Shivashankar (2015) [11] and Magadum *et al*. (2020) [2].

Table 1: Analysis of variance for leaf quality characters in mulberry germplasm

Source of variation	df	LMC (%)	LML after 3 hrs (%)	LML after 6 hrs (%)	LML after 12 hrs (%)	MRC after 3 hrs (%)	MRC after 6 hrs (%)	MRC after 12 hrs (%)
Replication	2	3.84	0.38	1.36	5.41	1.21	2.58	18.26
Treatment	17	36.39**	5.09**	29.10**	50.66**	15.73**	52.61**	136.84**
Error	34	3.49	1.42	3.88	2.37	2.64	8.01	3.50

** Significant at 1% level

LMC = Leaf moisture content; LML = Leaf moisture loss; MRC = Moisture retention capacity of leaf

Mean performance of mulberry genotypes

The mean performance of mulberry genotypes for leaf quality characters were statistically analyzed and presented in Table 2. Analyzed data indicated the presence of wide range of variability for all the characters studied.

Table 2: Mean performance of mulberry genotypes for different leaf quality characters

Genotypes	LMC (%)	LML after 3 hrs (%)	LML after 6 hrs (%)	LML after 12 hrs (%)	MRC after 3 hrs (%)	MRC after 6 hrs (%)	MRC after 12 hrs (%)
V1	75.15**	4.62	9.56*	24.63**	93.41	86.11*	66.20**
K2	69.28	5.50	10.31	25.77**	92.06	84.05	64.22**
Sujanpur local	71.75	5.87	12.13	34.51	92.02	83.49	52.99
Tr-10	72.75	6.29	10.46	25.69**	91.35	82.28	64.66**
Chak majra	62.37	6.79	12.69	28.56	89.10	79.65	54.19
Chinese white	68.13	5.13	10.59	26.56*	92.48	80.90	61.03*
S-146	72.39	6.08	13.91	25.27**	91.62	80.76	63.35**
C-4	74.41**	6.16	9.28*	27.80	93.32	83.50	65.28**
BR-2	70.38	6.26	13.69	27.86	91.12	80.56	60.42
AR-14	67.84	7.16	15.96	33.84	89.49	76.51	50.08
AR-12	68.61	9.71	19.18	33.37	85.86	72.04	51.36
AR-10	66.43	5.89	13.78	31.46	91.17	79.30	52.57
S-41	65.68	6.18	13.75	28.51	90.56	79.06	56.65
S-13	70.24	7.09	18.27	33.42	88.52	74.01	52.45
BC-259	70.51	4.96	10.61	26.88*	92.97	84.96	61.87*
S-1	67.96	6.81	16.20	35.01	90.97	76.05	48.55
MS-9404	69.12	7.87	16.20	36.77	87.11	76.59	46.67

S-1635	76.19**	3.87*	9.05*	24.18**	94.92**	87.13**	67.01**
Mean	69.96	6.24	13.09	29.45	91.00	80.39	57.75
S.Em	1.08	0.69	1.14	0.88	0.94	1.63	1.08
CD at 5%	3.10	1.97	3.26	2.55	2.69	4.69	3.10
CD at 1%	4.16	2.65	4.38	3.43	3.62	6.30	4.16

* Significant at 5% level and ** Significant at 1% level
LMC = Leaf moisture content; LML = Leaf moisture loss; MRC = Moisture retention capacity of leaf

Leaf moisture content (per cent)

The mean performance of 18 mulberry genotypes for leaf moisture content (per cent) ranged from 62.37 per cent (Chak majra) to 76.19 per cent (S-1635). When compared to the grand mean (69.96 per cent), nine genotypes recorded higher mean values. Higher leaf moisture content was recorded in S-1635 (76.19 per cent) followed by V-1 (75.15 per cent), C-4 (74.41 per cent) and S-146 (72.39 per cent), whereas Chak majra (62.37 per cent), S-41 (65.68 per cent) and AR-10 (66.43 per cent) recorded lower leaf moisture content.

Mulberry leaf quality is one of the key factors influencing the growth and development of silkworm, as the insect derives all the nutrients from mulberry leaf itself. The production of quality cocoon crop is directly correlated with mulberry leaf and it contributes towards successful rearing/quality cocoon production. Fotadar and Dandin (1997) [12] reported that the moisture content and moisture retention capacity varied among the genotypes. Mallikarjunappa *et al*. (2000) [14] evaluated four improved mulberry genotypes namely S-30, S-36, Viswa and M-5 for moisture content and moisture retention capacity. The leaf moisture content was significantly higher in Viswa (77.74 per cent) and S-36 (77.24 per cent) genotypes. These findings are in conformity with the reports of Sujathamma and Dandin (2000) [7], Tikader and Roy (2003) [8], Khan *et al*. (2007) [9], Jalaja Kumar and Rama Rao (2008) [10], Mohan *et al*. (2013) [14], Shivashankar (2015) [11], Kumar *et al*. (2018) [15] and Magadum *et al*. (2020) [2].

Leaf moisture loss (per cent)

The mean range of leaf moisture loss (per cent) after 3 hours of harvest varied from 3.87 per cent (S-1635) to 9.71 per cent (AR-12). Eight genotypes recorded lower mean values when compared to grand mean (6.24 per cent) for the trait. Lower leaf moisture loss after 3 hours of harvest was recorded in S-1635 (3.87 per cent) followed by V-1 (4.62 per cent) and BC-259 (4.96 per cent), whereas high moisture loss was recorded in AR-12 (9.71 per cent) followed by MS-9404 (7.87 per cent) and AR-14 (7.16 per cent).

The mean performance of all the mulberry genotypes studied for leaf moisture loss after 6 hours of harvest ranged from 9.05 per cent (S-1635) to 19.18 per cent (AR-12). When compared to grand mean (13.09 per cent), nine genotypes recorded lower mean values for the character. Lower leaf moisture loss after 6 hours of harvest was recorded in S-1635 (9.05 per cent) followed by C-4 (9.28 per cent) and V-1 (9.56 per cent), whereas the genotypes AR-12 (19.18 per cent) followed by S-13 (18.27 per cent), S-1 (16.20 per cent) and MS-9404 (16.20 per cent) recorded higher leaf moisture loss after 6 hours of harvest.

The mean range of leaf moisture loss after 12 hours of harvest varied from 24.18 per cent (S-1635) to 36.77 per cent (MS-9404). Eleven genotypes recorded lower mean values when compared to grand mean (29.45 per cent) for the character. Lower leaf moisture loss after 12 hours of harvest was recorded in S-1635 (24.18 per cent) followed by V-1 (24.63 per cent) and S-146 (25.27 per cent), whereas high moisture loss was recorded in MS-9404 (36.77 per cent) followed by S-1 (35.01 per cent) and Sujanpur local (34.51 per cent).

The quality of mulberry leaves pays a vital role in silkworm rearing. Inspite of growing the mulberry under ideal conditions, the leaves lose moisture to a considerable extent during the period the leaves are harvested and actually fed to the worms. The loss of moisture and withering of harvested leaves varies with different varieties and environmental temperatures. Availability of moisture content in leaves enhances feeding efficiency of silkworm larvae which in turn increases growth rate. Importance of dietary moisture content in relation to silkworm growth was emphasized that, decrease in leaf moisture content influenced different energetic parameters such as assimilation and conversion efficiency of food which decreases with decreasing dietary moisture content of leaf (Murthy *et al*., 2013) [16]. Mallikarjunappa *et al*. (2000) [13] reported that the leaf moisture loss at 6 hours after harvest was significantly less in S-36 and S-30 genotypes. The reports of Mallikarjunappa *et al*. (2000) [13], Murthy *et al*. (2013) [16] and Magadum *et al*. (2020) [2] were also in accordance with the results obtained in the present study.

Moisture retention capacity of leaf (per cent)

The mean performance of all the mulberry genotypes studied for moisture retention capacity after 3 hours of harvest ranged from 85.86 per cent (AR-12) to 94.92 per cent (S-1635). When compared to grand mean (91.00 per cent), eleven genotypes recorded higher mean values for the character. Higher moisture retention capacity after 3 hours of harvest was recorded in S-1635 (94.92 per cent) followed by V-1 (93.41 per cent) and C-4 (93.32 per cent), whereas the genotypes AR-12 (85.86 per cent) followed by MS-9404 (87.11 per cent) and S-13 (88.52 per cent) recorded lower moisture retention capacity after 3 hours of harvest.

The mean range of moisture retention capacity after 6 hours of harvest varied from 72.04 per cent (AR-12) to 87.13 per cent (S-1635). Ten genotypes recorded higher mean values when compared to grand mean (80.39 per cent) for the character. Higher moisture retention capacity after 6 hours of harvest was recorded in S-1635 (87.13 per cent) followed by V-1 (86.11 per cent) and BC-259 (84.96 per cent), whereas lower moisture retention capacity was recorded in AR-12 (72.04 per cent) followed by S-13 (74.01 per cent) and S-1 (76.05 per cent).

The mean performance of 18 mulberry genotypes studied for moisture retention capacity after 12 hours of harvest ranged from 46.67 per cent (MS-9404) to 67.01 per cent (S-1635). When compared to grand mean (57.75 per cent), nine genotypes recorded higher mean values for the character. Higher moisture retention capacity after 12 hours of harvest was recorded in S-1635 (67.01 per cent) followed by V-1 (66.20 per cent) and C-4 (65.28 per cent), whereas the genotypes MS-9404 (46.67 per cent) followed by S-1 (48.55 per cent) and AR-14 (50.08 per cent) recorded lower moisture retention capacity after 12 hours of harvest.

Moisture retention capacity plays an important role because

leaves with high moisture remain fresh and acceptable to silkworms for longer time and it is related to moisture content in leaves. Further, stomatal size and frequency play a major role in moisture retention in mulberry leaves (Murthy *et al*., 2013) [16]. Sujathamma and Dandin (2000) [7] reported that moisture content and moisture retention ability of leaves were found to be highest in variety Tr-10. The moisture retention ranged from 57.39 to 71.41 per cent in twenty three elite genotypes. Saha *et al.* (2004) [17] reported that variety S-1635 indicated better performance in response to leaf yield, leaf moisture retention capacity and rearing parameters. Susheelamma and Dandin (2006) [18] reported that the improved cultivars like V-1 exhibited higher moisture content and moisture retention capacity of leaf. Jalaja Kumar and Ram Rao (2008) [10] reported that leaf moisture content and moisture retention capacity were high in V-1 variety. These findings are in conformity with the reports of Tikader and Roy (2003) [8], Khan *et al*. (2007) [9], Mohan *et al*. (2013) [14], Murthy *et al*. (2013) [16], Shivashankar (2015) [11], Kumar *et al*. (2018) [15] and Magadum *et al*. (2020) [2].

Conclusion

It is concluded from the present study that there is adequate genetic variability existing in the genotypes studied for leaf quality characters. The mulberry variety S-1635 followed by V-1 and C-4 found to have higher leaf moisture content, lower leaf moisture loss and higher moisture retention capacity of leaf. These genotypes can be used as parents in the mulberry breeding programme for improvement and development of better leaf quality varieties.

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